BLOCK-TYPE BUILDING STONE USED AS A CONSTRUCTION MATERIAL FOR WALLS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the U.S. National Phase of International Application No. PCT/EP2004/010954, filed October 1, 2004, which claims priority to German Application No. DE 10 2004 044 003.4, filed September 9, 2004, and German Application No. DE 103 46 520.0, filed October 2, 2003, the contents of which are expressly incorporated by reference in their entirety as part of the present disclosure.

BACKGROUND

[0002] The invention relates to a block-type building stone used as a construction material for walls such as soundproof walls and building walls. The building stone has an outside face and an inside face.

[0003] The objective is to indicate a building stone that absorbs in the best possible way any kind of sound and is as little sound permeable as possible. The building stone should reflect as little sound as possible, at least on its inside face. The building stone finds application in conjunction with any kind of sound sources that are to be insulated against the environment such as a residential zone, so for example sound sources in industrial firms, sports centers and the like. An acoustic insulation may also be carried out inside a building. Generally, the building stone is intended to be used for external applications such as free-standing walls and outer building walls.

[0004] Block-type building stones are generally known. There also exist building stones made from layers, for example lightweight concrete building stones with a middle layer of foam such as polystyrene. For interior construction, polystyrene covered gypsum plasterboards are known.

SUMMARY OF THE INVENTION

[0005] It is the object of the invention to indicate a block-type building stone and a method of manufacturing same out of which walls can be built in a fast and simple manner and which comprises least possible sound permeability and highest possible sound absorption.

[0006] This object is solved by a block-type building stone comprising an outside face, an inside face and a three-layered structure. The three-layered structure includes an outer layer forming the outside face, a middle layer made from insulating mortar with high thermal performance that has at least 70 volume percent (related to the volume of the middle layer) of recycled, granular polyurethane and cement as a binder, and an inner layer that forms the inside face and preferably comprises cement as the binder. The block-type building stone is manufactured by first introducing a bottom layer into a water permeable mould to form either the outer layer or the inner layer. Next, cement, polyurethane and water are mixed together to produce a pourable mixture that is poured onto the bottom layer already formed in the mould to produce the middle layer. Next, a waiting time is observed wherein the cement does not yet harden and water flows out of the mould so that the layer thickness of the middle layer is reduced by at least 0.5 %, preferably by 2 to 5 %. Upon the expiration of the waiting period, an upper layer is applied; the upper layer forms the layer (outer layer or inner layer) not already formed by the bottom layer.

[0007] As noted above, the building stone is made from three different layers. The inner layer and/or the outer layer is either a continuous layer or a layer consisting of discrete larger parts such as e.g., bricks, ordinary stones, quarry stones, stone slabs (also marble, granite). In this case, the larger parts are pressed into the middle layer where they preferably adhere thanks to the cement of the middle layer. In use, these layers are positioned substantially vertically so that sound, which propagates substantially parallel to the earth's surface, is forced to pass through one layer after the other. Each layer has its own task to complete with regard to minimizing noise. It is preferred that the outer layer has the highest specific weight among the three layers; it is more specifically responsible

for blocking the sound. The middle layer has the lowest specific weight among the three layers and is responsible for damping. Preferably, the inner layer has a specific weight between that of the outer layer and that of the middle layer; it is responsible for absorption. The interfaces between the layers are also beneficial for the purpose of utilization because the transmission properties of sound change at the interfaces.

[0008] The building stone further has outstanding thermal insulating properties. This is more specifically due to the middle layer, which has a very low thermal conductivity of typically 0.05 W/m0K. This provides the building stone with a beneficial double function. It is light-weighted and easy to handle. It is also suited for do-it-yourselfers.

[0009] The inner layer is formed from mineral grains without superfines. As a result, it has open pores. The irregular grain structure reduces sound reflection from the surface thereof. The pore volume is preferably configured such that no water is allowed to accumulate within the structure of the inner layer so that frost damage and weed growth are prevented.

[00010] The middle layer is preferably chosen to be quite thick. In any case, it contributes little to the overall weight of the building stone so that said building stone can be configured to be quite large whilst still having a reasonable overall weight. It is preferred that the thickness of the middle layer be at least twice the thickness of the inner layer and/or the thickness of the outer layer. For the outer layer, one chooses a thickness that is beneficial to sound blocking without said outer layer determining too much the overall weight of the building stone. It has been found that layer thicknesses ranging from 4-14 cm are advantageous. The inner layer is preferably at least as thick as the outer layer and is preferably slightly thicker than the outer layer. For the inner layer, a coarse grain size ranging from 1 to 4 mm such as flint has prove advantageous.

[00011] In a preferred developed implementation, the middle layer comprises 90 – 94 volume percent of recycled hard polyurethane that is shredded to form a mixture of powder and granules having a grain size of preferably less than 8 mm and 6 – 10 volume percent of cement, more specifically 92 volume percent recycled hard polyurethane and 8

volume percent cement, each time related to the volume of the middle layer (24).

[00012] The block-type building stone preferably comprises an upper face and a bottom face. At least one projection is provided on the upper face and the bottom face comprises at least one recess that is at least the size of the projection on the upper face and conforms to the shape thereof. This allows for easy matching of the building stones during stacking. Continuous joints are avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

[00013] Other features and advantages of the invention will become more apparent upon reviewing the appended claims and the following non restrictive description of embodiments of the invention, given by way of example only with reference to the drawing. In said drawing:

[00014] FIG. 1 is a perspective illustration of a building stone of the invention;

[00015] FIG. 2: is a front view of a building stone in a second embodiment;

[00016] FIG. 3: is a perspective illustration of a building stone that is in parts a sectional view with the section line being transverse to the longitudinal direction, in a third embodiment of the building stone;

[00017] FIG. 4: is a front view of a building stone in a fourth embodiment;

[00018] FIG. 5: is a front view of a building stone in a fifth embodiment;

[00019] FIG. 6: is a front view of a building stone in a sixth embodiment;

[00020] FIG. 7: is a perspective illustration of a mould for manufacturing the building stone;

[00021] FIG. 8: is a top view on a top layer constructed from bricks;

[00022] FIG. 9: is a top view on a top layer constructed from rubble stones; and

[00023] FIG. 10: is a section taken along the section line X-X in FIG. 9.

DETAILED DESCRIPTION OF THE INVENTION

[00024] The building stone of FIG. 1 has an outer layer 20 made from self-compacting concrete. The specific weight typically is 2,400 kg/m³. At least 200 kg, preferably 300 kg, of cement are used per cubic meter. Said outer layer is a flat right parallelepiped of about 5 cm thick. The outer layer 20 forms an outside face 22 of the building stone. In use, this outside face is turned away from a noise source.

[00025] The outer layer 20 is adjoined with a middle layer 24. It is made from a material that has been described in U.S. Patent No. 5,904,763. This material has a quite low specific weight and, more specifically, a very low thermal conductivity. The disclosure of U.S. Patent No. 5,904,763 is fully incorporated herein by reference and pertains to the disclosure of the present application.

[00026] On its inside face, the middle layer 24 is adjoined with an inner layer 26. This layer also is flat and in the form of a right parallelepiped. The inner layer 26 forms an inside face 28 of the building stone. The inner layer 26 has a specific weight ranging from about 1,950 to 2,050 kg/m³. At least 100 kg of cement are used per cubic meter. A fraction of 200 to 250 kg cement is better. The inner layer has no zero fraction. The building stone further has a front end surface 30 and a rear end surface 32. The two end surfaces are identically built, the distinction between front and rear has only been made to better associate them with the FIGS.

[00027] In the exemplary embodiment shown in FIG. 1, the outer layer 20 and the inner layer 26 have the same thickness. The middle layer 24 has a thickness of about 15 cm, it thus is three times the thickness of the outer layer 20 or of the inner layer 26. The

thickness W of the building stone is about 25 cm, the length L ranges from about 30 – 250 cm, the height H is about 30 cm.

[00028] All three layers 20, 24, 26 are cement bound. This same type of bond also promotes the adhesion between the various layers. Further, the environmental stability of the building stone is substantially determined by the cement bond. Finally, the cement bond permits to keep the cost of manufacturing the building stone low.

[00029] The building stone of FIG. 1 has almost but not exactly the shape of a right parallelepiped. On the upper face, there is provided a tongue 34 that has a constant cross section and extends over the entire length L of the building stone. The cross section of the tongue is trapezoidal. The tongue 34 is only formed in the region of the middle layer 24; it extends over almost the entire width thereof. On the one hand, it is defined on either side toward the top by short inclined surfaces 36 sloping upward at an angle of 30° each. These inclined surfaces 36 commence at the interface between the middle layer 24 and a respective one of the adjacent layers 20 and 26. On the other hand, the tongue 34 is substantially bounded by a main surface 38 that is located above a terminating surface 46 of the outer layer 20 and inner layer 26, at a distance from said terminating surface ranging from between 0.5 and 8 cm, typically from between 2 – 5 cm.

[00030] In the bottom face of the building stone there is formed, corresponding to the tongue 34, a groove 40 that substantially conforms to the shape of the tongue 34. Also, the groove 40 is located in the middle layer 24 only and takes the entire width thereof. It also extends over the entire length L. The groove 40 preferably has dimensions that are slightly larger than the tongue 34, which makes it possible to provide, between groove 40 and tongue 34 of superposed building stones, a free space to dispose a glue, a mortar 42 (see FIG. 3) or an intermediate layer 44 (see FIG. 4). By way of example, a free space of about 3 mm is provided on all sides between the groove 40 and the tongue 34.

[00031] The tongue 34 and the groove 40 permit to achieve in a known way a shape association of superposed building stones. When the building stones are being superposed, the level terminating surfaces 46 of the respective one of the outer layer 20

and of the inner layer 26 come into surface contact. The outside faces 22 and the inside faces 28 of superposed building stones are aligned.

[00032] The building stones can be stacked one upon the other without having to glue or join them together by any other means. However, an adhesive or another binder may be interposed. This means may be provided between tongue 34 and groove 40 but it may also be provided between the terminating surfaces 46 of superposed outer layers 20 and inner layers 26 respectively. Direct, immediate contact between the respective terminating surfaces of the outer layers 20 and the inner layers 26 of superposed building stones is preferred, though. It is preferred that a binder is only applied onto the main surface 38 of the tongue 34.

[00033] In principle, a projection like the tongue 34 and a corresponding recess like the groove 40 need not be provided. If they are provided, they need not have the concrete shape as illustrated; there may also be provided isolated, cylindrical projections having mating recesses provided on the bottom face, and so on. Here, prior art mating projections and prior art mating recesses may be utilized.

[00034] Even if it is advantageous to have the projections and the recesses located in the region of the middle layer 24 only, this is not a limitation; the projections could as well be provided only in the layers 20 and/or 26 or also in these layers.

[00035] The projections and mating recesses permit to avoid direct, rectilinear joints between superposed building stones. This permits to generally improve sound insulation.

[00036] FIG. 2 shows quite small a building stone of an overall thickness W of about 12.5 cm. The outer layer 20 of concrete such as CEM I 52.5 is about 2.5 cm thick. Other concrete qualities such as B25/35 for example are possible. The inner layer 26, which is built from mineral grain with a granularity of 2-5 mm, has the same thickness. The middle layer 24 has a thickness W of about 7.5 cm. The stone has a height H of 20 cm and an overall length L of 60 cm. Such a stone can be lifted by hand, meaning no hoists are needed. The groove 40 on the bottom face is 2 cm deep, the tongue 34 on the upper

face protrudes 1.7 cm upward. The inclined surfaces 36 of the tongue 34 are at an angle of 45°.

[00037] In the exemplary embodiment of FIG. 3, there is illustrated a stone with an overall width W of about 25 cm, a height H of about 20 cm and a length L of about 40 cm. In this exemplary embodiment as well outer layer 20 and inner layer 26 have the same thickness. The thickness is about 5 cm. The remaining thickness is filled out by the middle layer 24. It is made from 80 volume percent of processed, shredded hard polyurethane and of cement as a binder. As shown in FIG. 3, an about 3 mm thick layer of mortar 42 is applied onto the main surface 34, said mortar layer providing a connection with a building stone that is placed on top of the building stone illustrated.

[00038] The building stone of FIG. 4 has an overall width W of about 50 cm and a height H of 40 cm. It is available in three different lengths L, namely of 0.6 m, 1.2 m and 1.8 m. The outer layer 20 and the inner layer 26 again have the same thickness of about 10 cm, with the remainder of the overall thickness, about 30 cm, being filled out by the middle layer 24. This layer is made from recycled, shredded hard polyurethane in a fraction of at least 85 volume percent (related to the middle layer) and from cement. Again, there is a groove 40 in the bottom face, said groove having a depth of 4 cm, and a tongue 34 on the upper face protrudes 3.7 cm. On said tongue 34, namely on the main surface 38 thereof, there is placed an intermediate layer 44 in the form of a rubber strip of approximately 3 mm thick. This allows for filling out the gap between tongue 34 and groove 40 of two superposed building stones. The acoustic and thermal properties improve simultaneously, with the building stones being finally fixed with respect to each other by the intermediate layer 44. If the rubber used for the intermediate layer 44 is a foam rubber, the thickness may be slightly more than 3 mm. If the intermediate layer 44 is compressible, its elastic properties can be made use of.

[00039] In the embodiment of FIG. 5, the building stone has a width of 60 cm; the height thereof is about 48 cm. There are different lengths, with the overall lengths available being 0.6 m, 1.2 m, 1.8 m and 2.4 m. The thickness of the outer layer 20, which is about 12 cm, is slightly smaller than the thickness of the inner layer 26. The middle layer is

about 36 cm thick; it is made from 90 to 94 volume percent of recycled, shredded hard polyurethane, with the remainder being cement. It more specifically consists of 92 volume percent recycled, shredded hard polyurethane with a grain size of less than 10 mm, preferably of less than 8 mm, and 8 volume percent of cement.

[00040] In the embodiment of FIG. 5, the tongue 34 protrudes quite far upward, with the main surface 38 of the tongue 34 being located 5.7 cm above the terminating surfaces 46 of the outer layer 20 and the inner layer 26. The groove 40 is configured accordingly to have a depth of about 6 cm.

[00041] The exemplary embodiment of FIG. 6 shows quite wide a building stone, with the overall width W being approximately 75 cm and the height H about 60 cm. In this case also, the available overall lengths L are 0.6, 1.2, 1.8 and 2.4 m. The thickness of the outer layer 20 and of the inner layer 26, which have the same thickness, is about 15 cm, with the thickness of the middle layer 24 being accordingly 45 cm. The inside depth clearance of the groove 40 is about 8 cm, the height of the tongue 34 about 7.7 cm. This building stone is suited for self-supporting soundproof walls that can be stacked sufficiently high without needing additional supporting means. Connection means between stacked building stones need not be provided. This facilitates assembly and disassembly of a soundproof wall.

[00042] FIG. 7 shows a mould 48 for manufacturing the building stones. During manufacturing, the layers are formed with an orientation that is different from the one used in subsequent application. The respective layers are horizontal, meaning that they are lying on top of each other in the mould once the building stone is finished. Generally, manufacturing starts with forming the outer layer 20, although it is also possible to proceed in reverse and to first build the inner layer 26.

[00043] As shown in FIG. 7, there is provided a suited mould 48 that already provides the shape of the tongue 34 and of the groove 40. Put another way, the mould 48 has the hollow space dimensions of the finished building stone. The mould 48 is open toward the top only where there is located either the inner layer 28 or the outer layer 22, which is preferred. The respective upper face is produced by processing it accordingly, for

example by leveling it at the upper edge of the mould 48. Later, the mould can be opened at a suited location (not shown) in order to remove the finished building stone; an end wall of the mould may be removed for example.

[00044] For manufacturing the building stone, the mould is first filled to the extent needed for the incline of a respective one of the groove 40 and the tongue 34 to be achieved. The corresponding layer is leveled. FIG. 7 shows several surfaces that are formed by the mould on the finished building stone (not shown in FIG. 7), namely e.g., 32, 34, 36, 38; this is to facilitate the understanding. If the need arises, the outer layer 20 may be compacted.

[00045] Next, the middle layer 24 is introduced before the lowermost layer has hardened. The thickness of this layer is also naturally limited by the mould, which is apparent from the tapering incline of a respective one of the tongue 34 and the groove 40. The material of the middle layer 24 is filled up to this level. Finally, the topmost layer, which preferably is the inner layer 26, is applied, with the middle layer 24 not yet being hardened. This permits to achieve a beneficial connection between the layers.

[00046] For manufacturing the middle layer, recycled, granular polyurethane, cement and water are intimately blended together, with water being added until the mixture is pourable. Generally, more water is added than is needed for hardening. When the prepared mixture is filled in for forming the middle layer, the surface of the middle layer levels out and water starts to flow out of the mould. It is allowed to rest for a while, this time being referred to as waiting time herein after. The waiting time should not be so long to allow the cement of the middle layer to harden. During the waiting time, water is flowing out and the cement starts to crystallize. The thickness of the layer diminishes. After typically 1 to 2 hours, generally between half an hour and five hours, shrinking of the middle layer is observed. The layer thickness is typically reduced by 2 to 2.5 %. The water flowing out of the mould is clean and virtually no cement is swept along by the water flow.

[00047] The shrinking of the middle layer 24 is a process that is typical for the invention.

Initially, the middle layer 24 has sufficient water to be capable of leveling and arranging itself on its own. What is particularly notable thereby is that virtually no cement is swept along by the water flowing out of the mould. The mould needs not be particularly fine-meshed to prevent cement from being swept along by the water flow. The water permeable mould only has to have openings small enough to prevent any fraction of polyurethane from passing through the holes.

[00048] The middle layer is typically produced in the following way. 100 liters of polyurethane and 20 liters of cement (ordinary blast furnace slag cement) are filled, together with 50 liters of water, into a compulsory mixer such as a job mixer or a screeding machine. The components are carefully blended. Then, 100 liters of polyurethane, 20 liters of cement and 50 liters of water are added once more. They are sufficiently blended. The mixture obtained is pourable. It exhibits the setting or shrinking that is characteristic for the invention.

[00049] Another possibility is to first dry blend polyurethane and cement and to add water only then. It is for example possible to dry blend 100 liters of polyurethane and 20 to 25 liters of cement in a screeding machine prior to adding water. Typically, the water is added in a fraction of about 50 % of the volume fraction of the polyurethane.

[00050] It is preferred to also wait for a while after the lower layer has been introduced into the mould. If the lower layer consists of concrete, shrinking is observed after a while. As already described in the steps described with regard to the middle layer 24, the time until shrinking occurs is dependent on the type of cement used. With rapid cement, the shrinking time is reduced. It is advantageous to pour the middle layer 24 onto the lower layer while the lower layer is still fresh but the cement has already started to harden, meaning the crystallization has already started.

[00051] Typically, the lower layer and the middle layer are continuous, meaning they show no gaps. The upper layer may also be configured in the same way but it may also be configured to have gaps. This will be explained with reference to the FIGS. 8 and 9.

[00052] In FIG. 8, bricks 50 or tiles are pressed at regular intervals into the middle layer 24; they form the outer layer 20. Upon pressing them into the middle layer 24, the material thereof rises slightly in the gaps between the discrete bricks 50 but does not reach the front face of the bricks 50. The bricks 50 are retained by the cement binder of the middle layer 24 so that no additional binder needs to be added. Still, additional binder may be added and it is for example also possible to apply a thin hardening layer of mortar, of glue or the like onto the middle layer 24 and to press the bricks 50 into the applied layer.

[00053] In the implementation as shown in the FIGS. 9 and 10, quite large rubble stones 52 are pressed into the still fresh but already set middle layer 24. They form the outer layer 20 and, at their end sides, the outside face 22. In this case as well, the material of the middle layer 24 rises in the gaps between the stones 52. This can be discerned from FIG. 10.

[00054] Concrete, open concrete, bricks 50, stucco, madder plaster (in German: Krapputz), exposed aggregate concrete, paving, plaster, lamellae and any type of natural and prefabricated stones such as marble slabs, concrete, paving stones, granite blocks, quarry stones 52 can be used as the outer layer 20.